PATENT SPECIFICATION

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DRAWINGS ATTACHED

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1281691

(54) IMPROVEMENTS IN ROTOR WINDINGS FOR DYNAMO-ELECTRIC MACHINES

(71) We, C. A. PARSONS & COMPANY LIMITED, of Heaton Works, Newcastle upon Tyne 6, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to rotor windings of dynamo-electric machines and particularly though not exclusively to rotor windings of large turbine driven generators of the kind used in power stations.

The form of winding in almost universal use for the rotor coils of such generators is a single layer winding known as a ' concentric coil winding ', but there are instances where a two layer winding commonly known as a ' diamond coil winding ' can be used with advantage for the rotor winding.

In a diamond coil winding for a turbogenerator rotor, the winding is disposed in straight longitudinally disposed slots in the surface of a cylindrical rotor core, there being two coil sides disposed one above the other in each slot. The upper coil sides distributed around the rotor constitute the upper layer of the two lawer form of winding and the lower coil sides the lower layer, the lower layer thus lying radially within the upper layer. The portions of the slot-embedded winding extending beyond the ends of the rotor core slots are commonly referred to as end windings and since, in the type of winding with which this invention is concerned, the end windings comprise extended conductor portions interconnecting the ends of the straight slot-contained conductor portions to form the coils of the winding, these extended conductor portions are hereinafter referred to as ' end connections '.

Our British Patent No. 1,129,606, describes a two layer winding for a rotor of a turbogenerator in which the end connections which interconnect conductors forming the coil sides are arranged in such a way that, irrespective of the number of conductors in each coil side, for each coil side the end connections are circumferentially disposed within a radial thickness equal to the radial thickness of an extended conductor portion forming one end connection. For the purposes of the present specification, the generally circumferential distribution of one or more end connections substantially within the radial extent of a single extended conductor thickness in the radial direction shall be referred to as a ' tier '.

Thus, in our aforementioned British Patent, there is always only one tier of end connections per coil side, and with an arrangement of two coil sides per slot there would be two tiers of end connections, one lying radially within the other.

In accordance with the present invention the end connections are arranged in such a manner that the number of tiers of end connections is a multiple of two with a minimum of four up to a maximum equal to twice the number of conductors in a coil side.

Thus, in a typical case, a rotor winding with two coil sides per slot and two conductors in each coil side has four tiers of end connections. In a winding with two coil sides per slot and three conductors in each coil side, the number of tiers of end connections can be four or six.

With two coil sides per slot and four conductors in each coil side the number of tiers of end connections could be four, six or eight. The end connections may be solid or hollow conductors and may have widths which are less than the width of the conductors which they interconnect.

The invention consists in a dynamo-electric machine having a multi-layer rotor winding in which conductors forming coil sides of the winding are disposed in slots in a core for the winding in a number of radially spaced layers, the radial depth of a coil side corresponding to the radial depth of a layer and there being two or more radially spaced conductors in each coil side, in which machine the end connections (as herein-before defined) between slot-embedded portions of the winding

conductors are arranged so that an even number of tiers of end connections is formed disposed beyond each end of the core slotted region, the tiers being mutually radially spaced apart and the number of tiers at each end of the core having a minimum of four and a maximum equal to twice the number of conductors in a coil side.

The invention also consists in a dynamo-electric machine in accordance with the preceding paragraph in which the rotor has a two layer winding and at one end of the winding the end of the end connection extending from the radially innermost conductor of each lower coil side or from the radially outermost conductor of each upper coil side is short pitched by one slot pitch so as to lie radially in line with the end of at least one end connection extending from a conductor of an adjacent slot.

The invention further consists in a dynamo-electric machine substantially as described herein below with reference to drawings.

In order that the invention can be more clearly understood various embodiments thereof will now be described with reference to the drawings in which:—

Figure 13 is a drawing accompanying this specification; and

Figure 1—12 and 14—20 are drawings accompanying the Provisional specification.

In the drawings:—

Figure 1 is a diagrammatic representation of one half of a two-layer rotor winding in accordance with one embodiment of the invention for a turbo-generator with two coil sides per slot and two conductors per coil side;

Figure 2 is an end view of the end connections at therearend of the winding of Figure 1 looking in the direction opposite to that of arrow Z;

Figure 3 is a side elevation of the connections shown in Figure 2;

Figure 4 is an end view looking in the direction of arrow Z of the end connections at the front of the winding;

Figure 5 is a side elevation of the connections shown in Figure 4;

Figure 6 is a section through a rotor slot;

Figures 7—12 inclusive are views similar to those of Figures 1—5 for an alternative form of winding with two coil sides per slot and three conductors per coil side;

Figures 13—18 inclusive are views similar to those of Figures 1—5 for a further type of two-layer winding with two coil sides per slot and four conductors per coil side;

Figure 19 is a perspective view of parts of slot conductor strands and end connections in accordance with an embodiment of the invention;

Figure 20 is an exploded view of the conductors of Figure 19.

In carrying the invention into effect in the forms illustrated by way of example and referring first of all to Figures 1—6 one half of a two layer rotor winding of a turbo-generator is represented in a developed view. In the example illustrated the rotor slots are numbered 1—15 with slots 7—9 and 16—18 omitted.

Six diamond coils are shown each with two conductors per coil side. The coil sides in the upper part of the slots are shown by continuous lines and the coil sides in the lower part of the slots are shown dotted. The other six coils have been omitted but the upper coil side of the first coil would lie in slot 10 and the lower coil side of the coil would lie at the bottom of slot 1 and so on in accordance with conventional practice with two layer windings. The upper coil side has conductors A and B whilst the lower coil side has conductors C and D. The slot embedded portions of the conductors are represented by portions of the lines such as A, B, C & D which lie between the lines XX and YY, the lines XX and YY corresponding to the core slot ends, whilst the portions of the conductors constituting the end connections are represented by the portions of the lines lying beyond the area bounded by lines XX and YY. The extreme ends of the end connections are represented by *a*, *b*, *c* and *d* herein called the front end winding and by *a′*, *b′*, *c′* and *d′* for the other end winding herein called the rear end winding.

Referring to Figures 1, 4 and 6, end *a* of conductor A in coil side S_1 is connected to an external supply of d.c. excitation current and the flow path for current is then through conductor strand A of coil side S_1 to end *a′* of the same conductor at the rear end of the winding. Connected to end *a′* is an end link L_1 (Figure 2) which connects end *a′* of conductor A to end *c′* of conductor C the latter lying in slot 10. End *c* of conductor C is connected to end *b* of conductor strand B lying in slot 1 by end link L_2 (Figure 4).

The current then flows through conductor B to end *b′* thereof where it passes through link L_3 to end *d′* of conductor D lying in slot 10. It then flows through conductor D to end *d* of conductor D. End *d* is short pitched by one slot pitch, as shown, so as to lie radially in line with ends *c*, *b* and *a* of the conductors of the next following coil. End *d* is connected by link L_4 to end *a* of conductor strand A in slot 2 and the process is then repeated until finally the current passes from end *d* of conductor D in slot 15 through an external connection to the other half of the winding whose connections are identical with those just described.

The true disposition of the links L_1, L_2, L_3 and L_4 can best be seen from Figures 2—5. In Figure 1 the disposition of the links is diagrammatic.

Basically each row of end connections end-

ing at *a, b, c* or *d* represents a tier of end connections. Thus in the embodiment illustrated for a two-layer winding with two conductors per coil side there are four tiers of end connections. The chief advantage of this arrangement, compared with the two layer winding described in our British Patent No. 1,129,606, is that the radial depth of each end connection is less, and the thickness greater so providing a better mechanical stability for the winding. It is also more suitable when using hollow end connections cooled by internal flow of coolant, since axial access to the end connections is facilitated.

A further advantage of the arrangement shown compared with conventional two layer windings with more than two conductors per coil side is that by connecting the conductors in the manner described and short pitching the end of the radially innermost conductor of the lower coil side, the extreme ends of the connections can be kept radially in line and the cross connections between coils are of simple construction being essentially straight, radially disposed, links, which join the ends of the end connections. Such an arrangement leads to increased compactness and facilitates packing of the winding against the effects of centrifugal forces.

As an alternative to the arrangement of links shown in Figures 2—5, if there is sufficient space in a circumfernetial direction between, for example, ends *a'* of slots 1 and 2 to accommodate link L_3, the lengths of the corresponding end connections *b'* and *d'* can be adjusted so that link L_3 lies between the two links L_1 of slot 1 and 2. Links L_1 and L_3 would then lie in the same axial plane, as opposed to the arrangement shown in Figure 3 when they lie in two different axial planes. Similar adjustments could be made to the other end winding to bring links L_2 and L_4 axially in line. The overall axial length of the end windings would be reduced if the additional axial length of the end connections ending at *b'* and *d'*, *b* and *c* were less than the axial width of the links.

Figures 7—12 show an arrangement for a two-layer winding with two coil sides and three conductors per coil side. It will be seen that there are six tiers of end connections at each end of the rotor. The conductors are connected in the sequence CDBEAF, to give minimum voltage between conductors in any coil side and the most simple link arrangement. Thus of the six links per slot, five are straight, radial connectors and only one, between *F* and *C* requires to be formed to lie to one side of the other links. If the order were, for example ADBECF only two of the links could be straight and four would have to be formed in the manner of the links between *F* and *C*.

Figures 13—18 show another arrangement for a two-layer winding with two coil sides each having four conductors. The number of tiers of end connections is four. The conductors are connected in the sequence A, E, B, F, C, G, D, H. It will be seen that the end connections G and H are effectively transposed from one end winding to the other to obtain a simpler more uniform arrangement of the links L and at the same time maintain minimum voltage between adjacent conductor strands in the slot limited to the voltage on one turn.

Figures 19 and 20 show a typical arrangement for effecting a transposition of the conductors G and H. The portions E', F', G' and H' represent the slot embedded portions of each conductor and the portions forming the end windings are slotted into position in the manner shown.

With the arrangements in accordance with the invention the links L can be of simple form, are easy to support and occupy the minimum axial space.

WHAT WE CLAIM IS:—

1. A dynamo-electric machine having a multi-layer rotor winding in which conductors forming coil sides of the winding are disposed in slots in a core for the winding in a number of radially spaced layers, the radial depth of a coil side corresponding to the radial depth of a layer and there being two or more radially spaced conductors in each coil side, in which machine the end connections (as hereinbefore defined) between slot-embedded portions of the winding conductors are arranged so that an even number of tiers of end connections is formed disposed beyond each end of the core slotted region, the tiers being mutually radially spaced apart and the number of tiers at each end of the core having a minimum of four and a maximum equal to twice the number of conductors in a coil side.

2. A dynamo-electric machine as claimed in Claim 1 in which the rotor has a two layer winding and at one end of the winding the end of the end connection extending from the radially innermost conductor of each lower coil side or from the radially outermost conductor of each upper coil side is short pitched by one slot pitch so as to lie radially in line with the end of at least one connection extending from a conductor of an adjacent slot.

3. A dynamo-electric machine substantially as described herein-above with reference to Figures 1 to 12 and 14 to 20 of the drawings

accompanying the Provisional Specification and with reference to the accompanying drawing.

MARKS & CLERK,
Chartered Patent Agents,
Agents for the Applicant(s).

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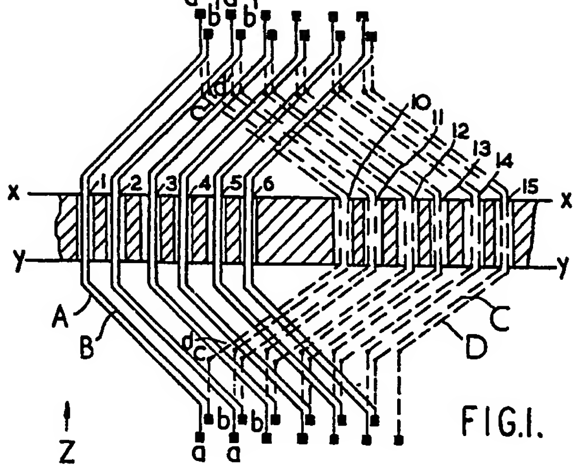


FIG.1.

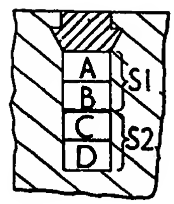
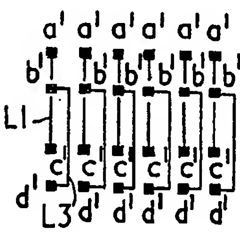


FIG.6.

FIG.2.



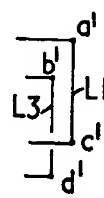
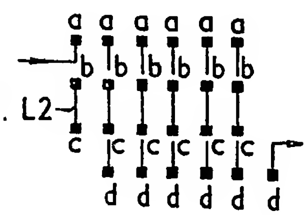


FIG.3.

FIG.4.



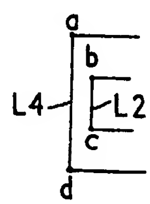


FIG.5.

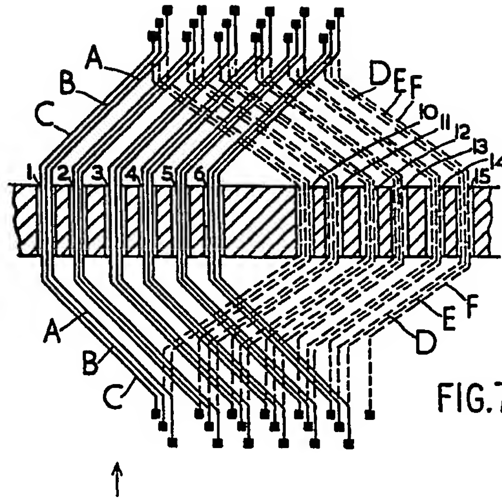


FIG.7.

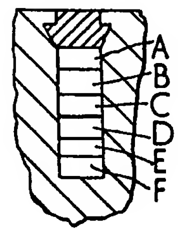
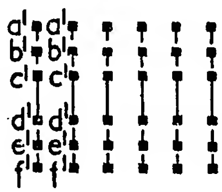


FIG.12.

FIG.8.



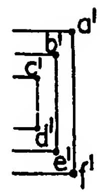
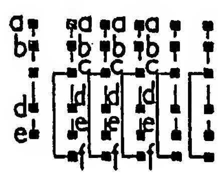


FIG.9.

FIG.10.



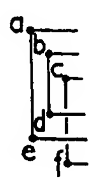


FIG.11.

1281691 PROVISIONAL SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

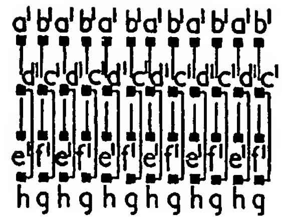


FIG.14.

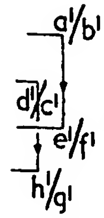


FIG.15.

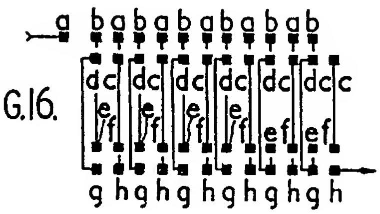


FIG.16.

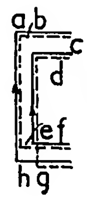


FIG. 17.

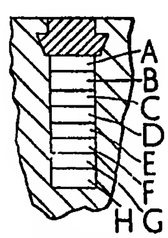


FIG. 18.

1281691 PROVISIONAL SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 4

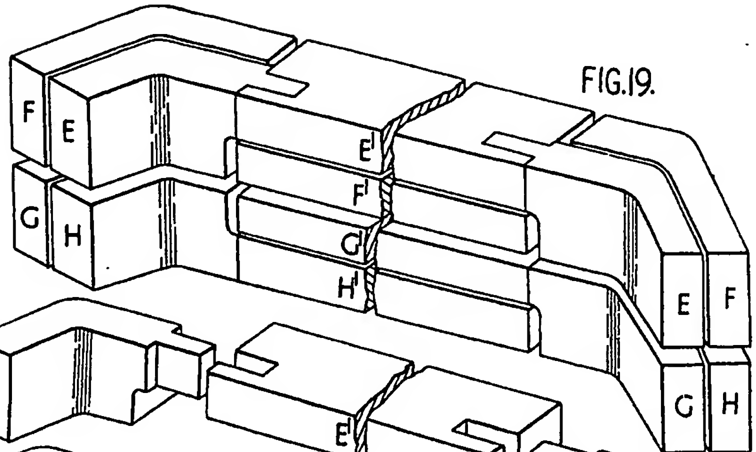


FIG.19.

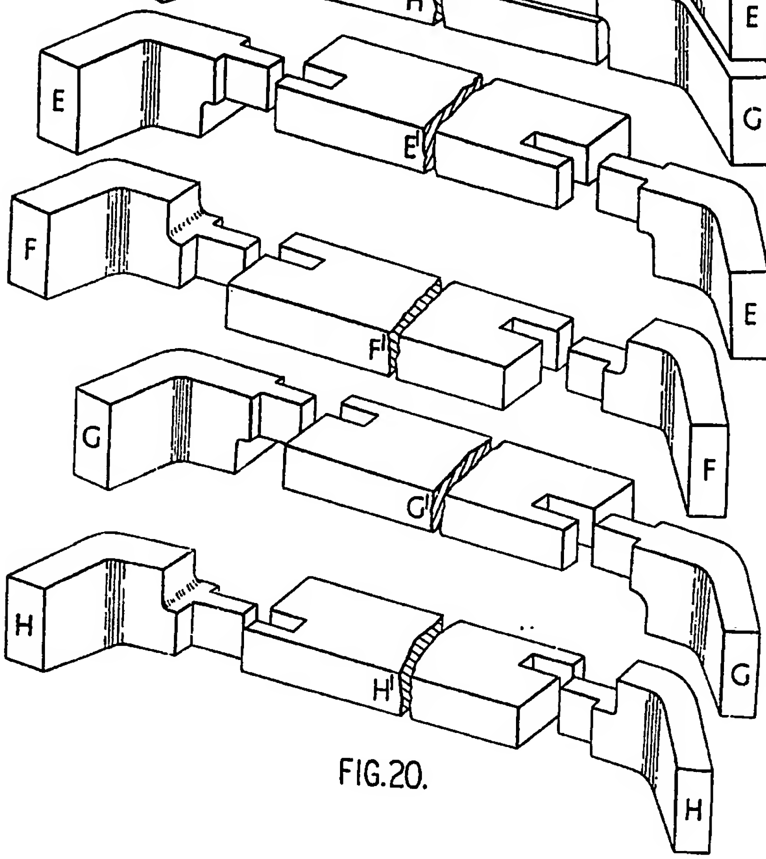


FIG.20.

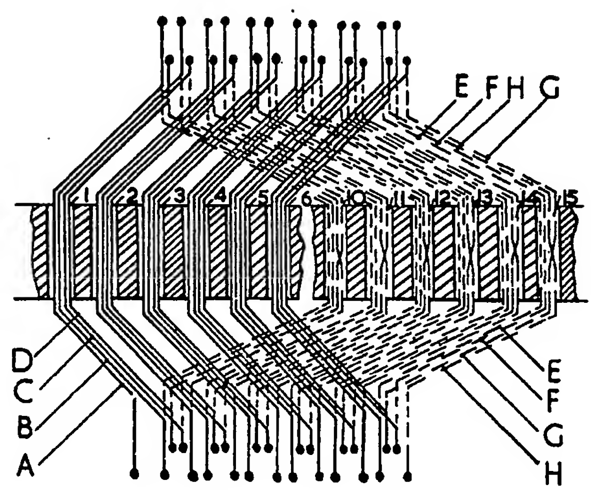


FIG. 13.